



Wastewater  
Treatment  
Facility

# Wastewater Treatment Plant *Master Plan*

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## Section 5 DRAFT

### Disinfection

#### 5.1 Existing Disinfection Facilities

The WWTF previously had chlorine gas disinfection of its effluent. The WWTF only needs to disinfect its effluent from March 15 to November 15. Due to the increased health and safety concerns of using chlorine gas, the existing chlorine gas system was replaced with bulk sodium hypochlorite for chlorination and sodium bisulfite for dechlorination as part of the Phase 1A upgrades. As part of the Phase 1A upgrades, online colorimetric monitors were installed to provide a continuous measurement of the total chlorine residual in the contact basin and after dechlorination. However, one of the sample supply pumps was never installed in the contact basin, therefore the chlorine analyzers were never used. The original control strategy in the design documents was for flow control with the analyzers used for monitoring only. Flow pacing is where a desired pumped chlorine concentration is set and the computers increase or decrease the chemical metering pump flow based on facility effluent so that the pumps are always pumping a consistent concentration of chlorine into the system. It did not appear that this control system had been programmed into the supervisory and data acquisition system (SCADA). The operators are relying on manual grab samples for total residual chlorine and manually set the flow of the pumps to a fixed value.

#### 5.2 Chlorination Problems

After the Phase 2 improvements went online in February of 2011, facility staff began to notice some irregularities with their chlorine doses. One day they were able to reduce their fecal coliform below permit limits and the next day the fecal count was above the limit even though the pumped chemical and facility flows were the same. Conversations with facility staff did reveal that this occasionally happened prior to the Phase 2 upgrades, but that they were occurring more frequently after the MLE process was in operation.

The issue was that the MLE process was installed to reduce the ammonia concentration in the WWTF by converting it to nitrite, then to nitrate, and ultimately to nitrogen where it will be off gassed from the system. Historically, chlorine disinfection in wastewater treatment facilities has relied on the ammonia present to form chloramines, which are not as aggressive as free chlorine. Chloramines are more stable than free chlorine and do not typically result in excessive chlorine demands. If there is no ammonia to form chloramines, then the chlorine dose will need to be increased to form free chlorine. However, in some WWTFs there are additional compounds present, such as nitrite, organic nitrogen, color, etc. that the free chlorine will quickly oxidize before a free chlorine residual can be established for disinfection. In some cases, this may result in a required chlorine dose of 15 to 20-mg/L.

#### 5.3 Approach

The approach used to evaluate a situation like this is to analyze existing data and monitor effluent for additional parameters that may be inhibiting disinfection. From the data, it should be determined whether there is enough ammonia to form chloramines, or whether it is possible to use a free chlorine residual. The next option is to consider adding ammonia into the system. If these do not work, then additional disinfection alternatives should be analyzed and piloted.

## 5.4 Monitoring Data and Sampling

If there is a consistent concentration of 1 to 3-mg/L of ammonia upstream of the chlorine contact basin, then it is possible to form a stable chloramine residual if the chemical is flow paced. If the concentration is less than one or extremely variable, then a chloramine dose will not be possible. The WWTF's effluent data does not provide an accurate account of the compounds present because some of them are oxidized in the chlorine contact basin. Therefore special sampling was requested as shown in **Table 5-1**.

**Table 5-1. Final Clarifier Effluent Sampling for Disinfection Study**

Date	Flow (mgd)	pH (SU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Fecal (col/100 ml)	TKN (mg/L)	Organic-N (mg/L)
5/14/12	12.4	7.1	0.1	4.3	2.0	16,000	---	---
5/15/12	13.2	7.0	3.1	4.7	11.0	---	3.4	0.3
5/16/12	13.0	7.0	2.9	6.3	2.0	35,000	5.2	2.3
5/17/12	13.7	7.1	1.6	8.3	3.0	---	3.4	1.8
5/21/12	13.3	---	---	---	---	35,000	3.7	---
6/4/12	---	7.0	0.2	3.4	1.0	7,000	2.1	1.8
6/5/12	---	7.2	1.7	0.7	3.0	---	3.6	1.9
6/6/12	---	7.2	1.8	5.1	7.0	3,300	3.6	1.8
6/7/12	---	7.2	0.6	6.4	3.0	---	2.3	1.8
6/8/12	---	7.3	0.4	2.9	4.0	92,000	2.9	2.4
<b>Min</b>	12.4	7.0	0.1	0.7	1.0	3,300	2.1	0.3
<b>Max</b>	13.7	7.3	3.1	8.3	11.0	92,000	5.2	2.4
<b>Avg</b>	13.1	7.1	1.4	4.7	4.0	31,383	3.4	1.8

mgd = million gallons per day

mg/L = milligrams per liter

col/100 ml = colonies per 100 milliliters

SU = standard unit

The sampling revealed that on some days there was sufficient ammonia to form chloramines, however there are times when the ammonia concentration drops below 1-mg/L. Due to the inconsistent ammonia concentration, a stable chloramine dose cannot be formed. In addition, the data shows a high concentration of nitrites, which should be less than the nitrates. Nitrites have a high chlorine demand that takes five parts of chlorine to oxidize one part of nitrite. The presence of nitrites over nitrates was also an indication that there was toxicity or upset conditions in the MLE process hindering the bacteria from completing the full two step nitrification process. Organic nitrogen was also present upstream of the contact basins, which can also exert a chlorine demand.

Additional data provided by the operation staff in **Table 5-2** shows the varying conditions for chlorine disinfection at the WWTF.

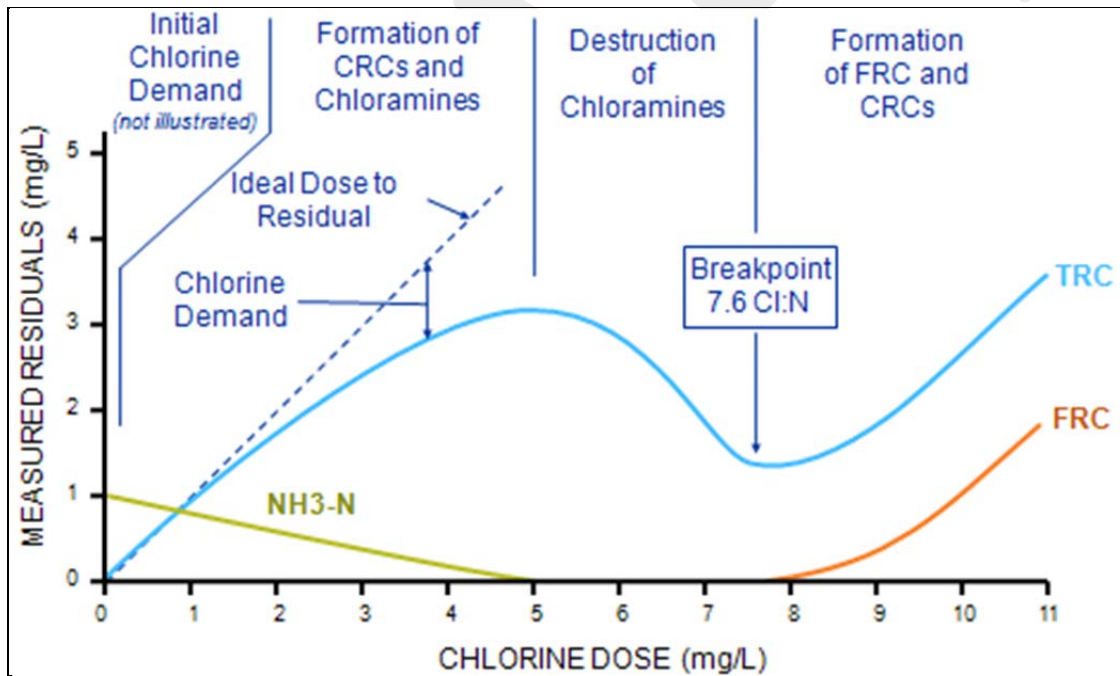
**Table 5-2. Chlorine Contact Basin Effluent Sampling**

Date	Flow (mgd)	TSS (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Fecal (col/100ml)	Chlorine Dose (gph)	Chlorine Dose (mg/L)	TRC (mg/L)	FRC (mg/L)
7/2/12	13.2	4.4	<1.0	1.6	5	20	42.3	9.62	>2.2	1.23
7/10/12	13.6	11.4	6.5	6.8	5	800	60	13.25	1.59	0.42
7/16/12	12.9	6.8	1.4	---	---	20	70	16.32	>2.2	1.25
7/18/12	13.8	8.9	3.2	6.2	7	---	---	---	---	---
7/23/12	12.5	9.9	<1.0	---	---	500	70	16.74	1.64	1.29
7/24/12	13.2	11.6	7.9	5.3	3	---	---	---	---	---
7/30/12	12.3	7.4	<1.0	---	---	20	95	23.26	>2.2	1.81
7/31/12	13.3	8.8	2.7	3	5	---	---	---	---	---

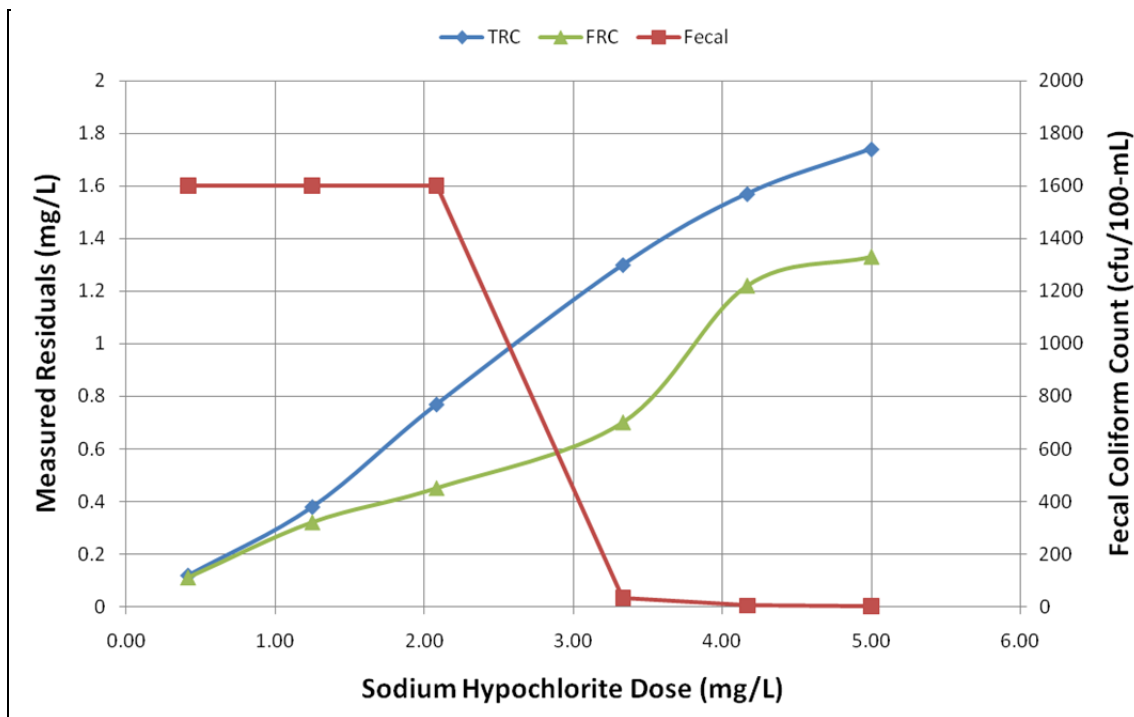
Notes:

Chlorine dose in-mg/L is based on a sodium hypochlorite trade concentration of 12.5 percent.

The WWTF also conducted a breakpoint curve analysis on their effluent to validate the research that there should be a high demand at breakpoint when the free residual chlorine begins to form. See **Figure 5-1** for a typical breakpoint curve based on 1-mg/L of ammonia nitrogen (NH<sub>3</sub>-N) present.

**Figure 5-1. Typical Breakpoint Curve at 1-mg/L of NH<sub>3</sub>-N**

The sample for the breakpoint was taken on August 2, 2012 and there was no ammonia present, 2.2-mg/L of organic nitrogen, 4.2-mg/L of nitrate, and 2.0-mg/L of nitrite. Seven different spots were measured on the curve and are shown in **Figure 5-2**.



**Figure 5-2. Breakpoint Curve of the August 2, 2012 Sample**

Figure 5-2 showed that a dose of 3.3-mg/L was sufficient to reduce the fecal coliform count to 33-cfu/100-mL. No chlorine demand was exhibited at breakpoint. While this sample illustrated that free chlorine formed quickly with little demand, the data in Table 5-2 also shows that these conditions can change on a daily basis. Therefore, relying on a consistent ammonia concentration from the final clarifiers or relying on free chlorine is not possible.

## 5.5 Add Ammonia

Free chlorine prefers a reaction with ammonia over other compounds that may be present. That is why chloramines have worked so well as a disinfectant in wastewater for a long time. Therefore, in order to restore stability to the disinfection system, ammonia can be added immediately upstream of disinfection. This has been performed at other WWTFs whether to help with disinfection or to reduce the amount of disinfection byproducts which are formed more readily with free chlorine. Ammonia can be added in from screened primary clarifier effluent, or from a separate aqueous ammonia feed. The aqueous ammonia feed can provide a more controlled dose of ammonia over the primary clarifier effluent. A small concentration of ammonia, around 2-mg/L, is needed.

A quick analysis was performed that compared the use of 12.5 percent trade sodium hypochlorite at a high chlorine dose of 16-mg/L to the use of sodium hypochlorite at 8-mg/L with 2-mg/L of 29.4 percent aqueous ammonia. An average flow of 13-mgd over the course of 245 days was used. The cost for sodium hypochlorite is \$1.10/gallon and for aqueous ammonia is \$1.55/gallon. Based on this analysis, there would be a savings of \$190,000 per year by using ammonia plus chlorine in lieu of a high dose of chlorine.

In the presence of looming nutrient limits, the addition of ammonia to WWTF effluent adds to the TN value. Therefore, adding ammonia is a low cost stopgap solution until nutrient limits are required and to allow additional evaluation of the system.

## 5.6 Other Disinfection Technologies

The other options that are typically considered for disinfection of WWTF are chlorine dioxide, ozone, ultraviolet (UV), ferrate, peracetic acid (PAA), and advanced oxidation practices. The disinfection alternatives that are commonly selected for further disinfection studies are ozone, UV, and PAA, which are described in more detail below.

### 5.6.1 Ozone

Ozone disinfection has been used in Europe for decades, but does not have widespread application for wastewater disinfection in the United States, largely because of much higher capital and operation costs as compared to other disinfection alternatives. Ozone has been primarily used for potable water disinfection, which typically has a much lower ozone demand than wastewater, and can be applied for primary disinfection credit at reasonable doses (2 to 4-mg/L).

### 5.6.2 UV Disinfection

The use of UV for disinfecting treated wastewater is widespread in the United States, and, in fact, has become the favored technology for new or upgraded WWTFs. There are reportedly over 3,500 UV wastewater disinfection systems currently operating in North America, treating flows of up to 300-mgd. UV disinfection eliminates the operational and environmental hazards associated with the use of chlorine compounds (and sulfite compounds when dechlorination is required), and does not produce harmful disinfection by-products. As with the use of free chlorine, there are a number of compounds that will interfere with UV disinfection and reduce the UV transmittance (UVT). Also, typical TSS values should not exceed 20-mg/L in order to prevent the absorbing and scattering of UV light, which can lead to lower UVT. UV disinfection has a high capital cost, however when a lifecycle analysis is performed, UV disinfection compares very well to a new bulk sodium hypochlorite system.

### 5.6.3 Peracetic Acid

PAA has been used as a wastewater disinfectant in Europe and South America, but has not seen widespread use for wastewater disinfection in the United States. PAA is a strong disinfectant with a wide spectrum of antimicrobial activity. The desirable attributes of PAA for wastewater disinfection are that the chemical is purchased and stored on site, does not form persistent toxic or mutagenic residuals or by-products, no quenching requirement (i.e., no dechlorination), small dependence on pH and short contact time. Major disadvantages associated with PAA disinfection are the increases of organic content in the effluent due to acetic acid and its high cost, which is partly due to limited production capacity worldwide. A recent disinfection technology alternative study conducted by CDM Smith showed PAA to be a prime candidate for full scale disinfection, however further testing is required before implementation.

## 5.7 Next Steps

Based on the sampling and analysis performed on the WWTF, it appears difficult to continue using sodium hypochlorite disinfection without the addition of ammonia to form chloramines. It is recommended that additional sampling and monitoring of the final clarifier effluent be conducted on a routine basis to establish a long trend line of conditions immediately upstream of disinfection.

Additionally, sampling for UVT is recommended if the City is considering alternative technologies. The use of ammonia feed to supplement the existing sodium hypochlorite system would be the easiest to implement and a low cost disinfection solution, however, this system should be piloted before placing into operation.